FORCE

Wireless 101 – Changes in Technology

FORCE USA Online University

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Myths About Wireless

- Is wireless communication reliable?
- Is wireless secure?
- Is wireless comparable to fiber? (Speed & Latency)
- Is it expensive to have licensed wireless?

Why Wireless?

- **Cost Reduction** – Extremely Quick ROI / Low CAPEX
- **Greater Bandwidth** (GigE+ Full Duplex)
- **Last Mile Connectivity** – Bandwidth where you can't get it
- **Network Design Flexibility**
- **No Right of Way Issues** – No long term land or aerial leases
- **Greater Reliability** – up to 99.999% (<5min)
- **Complete Redundancy** - (1+1, 2+0, 3+0, 4+0)
- **Eliminate Dependency –** Third Party or Telco's
- **Greater Security** – DOD Specs / Eliminate VPN Connections
- **Quick Provisioning Time**
- **Mobility** – Real IP data in vehicle

Wireless Use

- High Bandwidth Backhaul
- IP / T1 connectivity
- Voice (Fixed, VoIP, and Mobile)
- SCADA backhaul
- Access Control
- Video Surveillance
- Remote Access
- Revenue Generation

Wireless Explained

Types of Wireless Systems

- **Point to Point Backhaul (“PtP”)** – Connecting two locations.

- **Point to Multi Point (“PtMP”)** Typical Base Station Unit (“BSU”) talking to Multi Subscriber Unit (“SU”) end node locations.

- **Mesh** – Multiple radio to radio links based on a switching protocol. Used in fixed locations.

- **Mobile** – Basically the same as PtMP but allows for mobility of SU devices.

Communication Explained

- **Full Duplex**
  - Communication in both directions at the same time
- Half Duplex
  - Communications in one direction at a time
- **Frequency Division Duplex (FDD)**
  - Communications in one direction are at a **different frequency** than in the other direction
- Time Division Duplex (TDD)
  - Communications in one direction are at a different time than in the other direction, transmitting and receiving at the **same frequency**.

Communication Explained

Example:

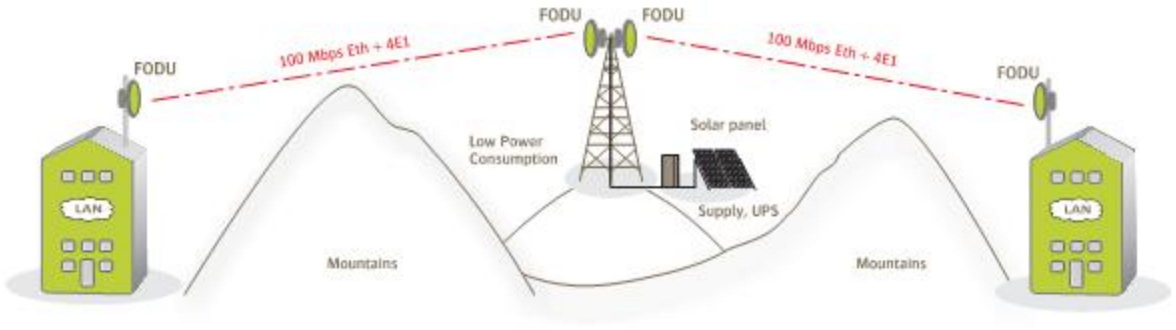
100Mbps Full Duplex is equivalent to 200Mbps Aggregate Throughput

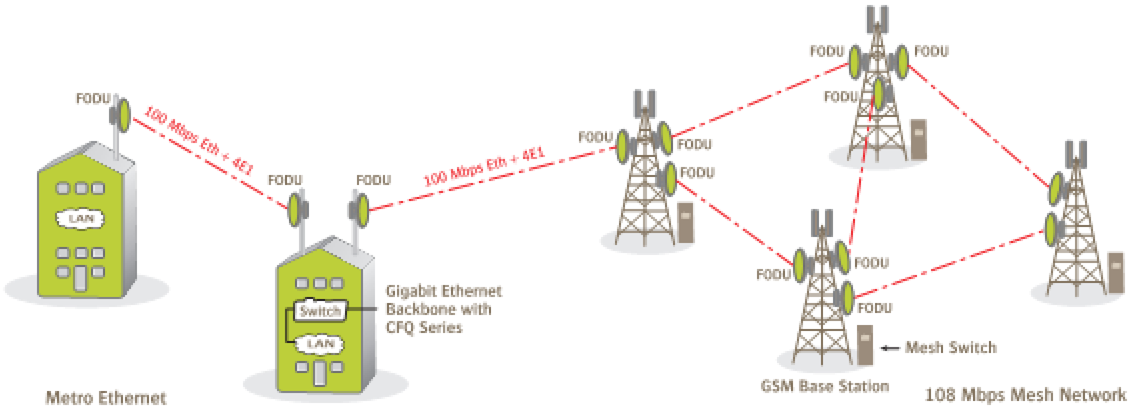
Or

100Mbps Aggregate Throughput is equivalent to 50Mbps Full Duplex

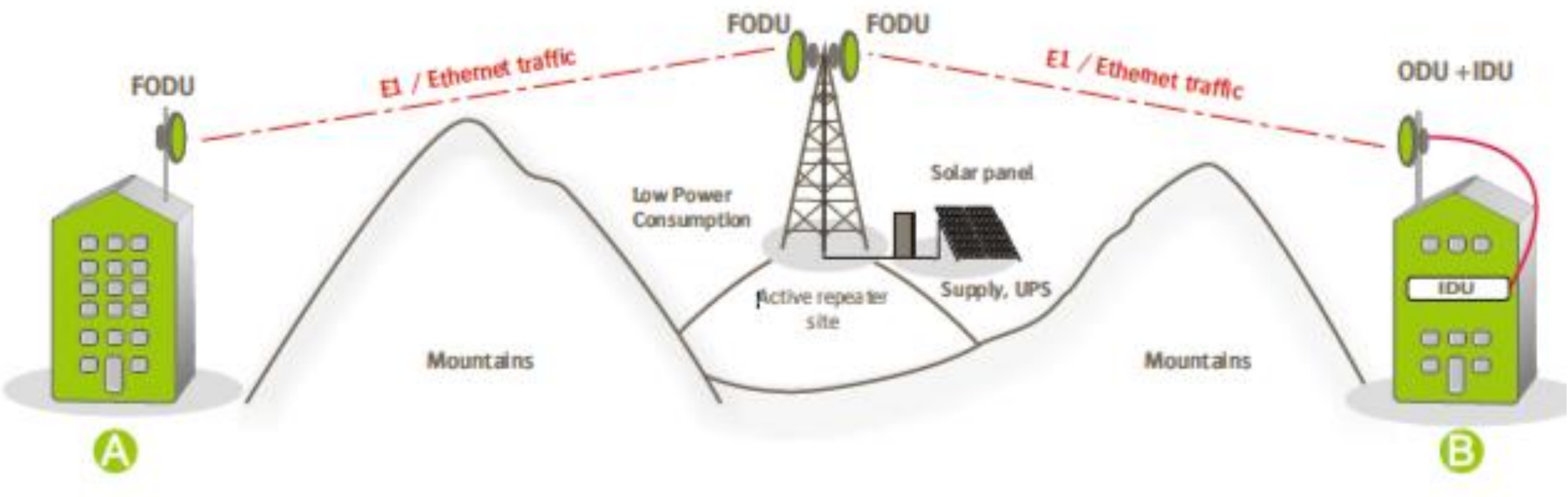
Wireless Backhaul

Flexible Topologies





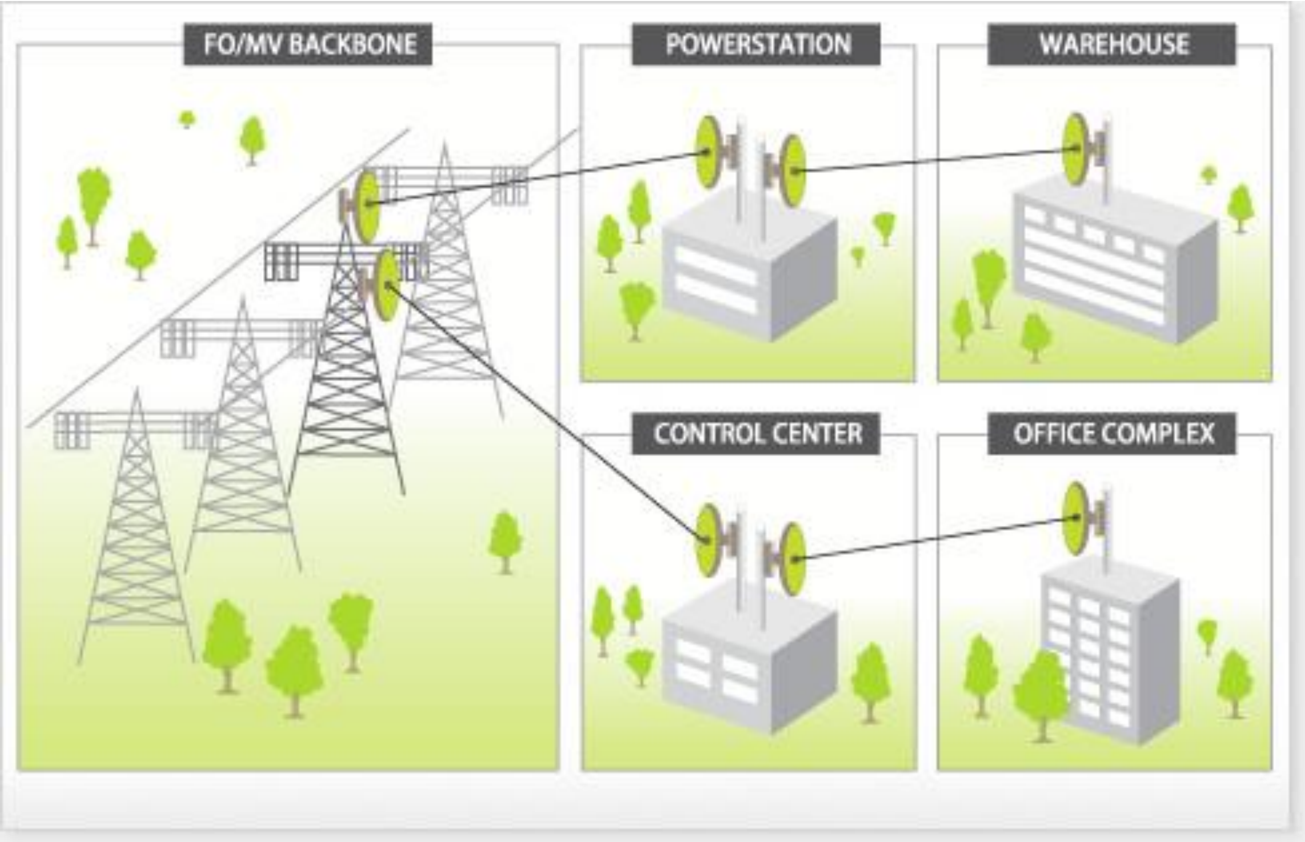
Ability to Cover Distances and Obstructions



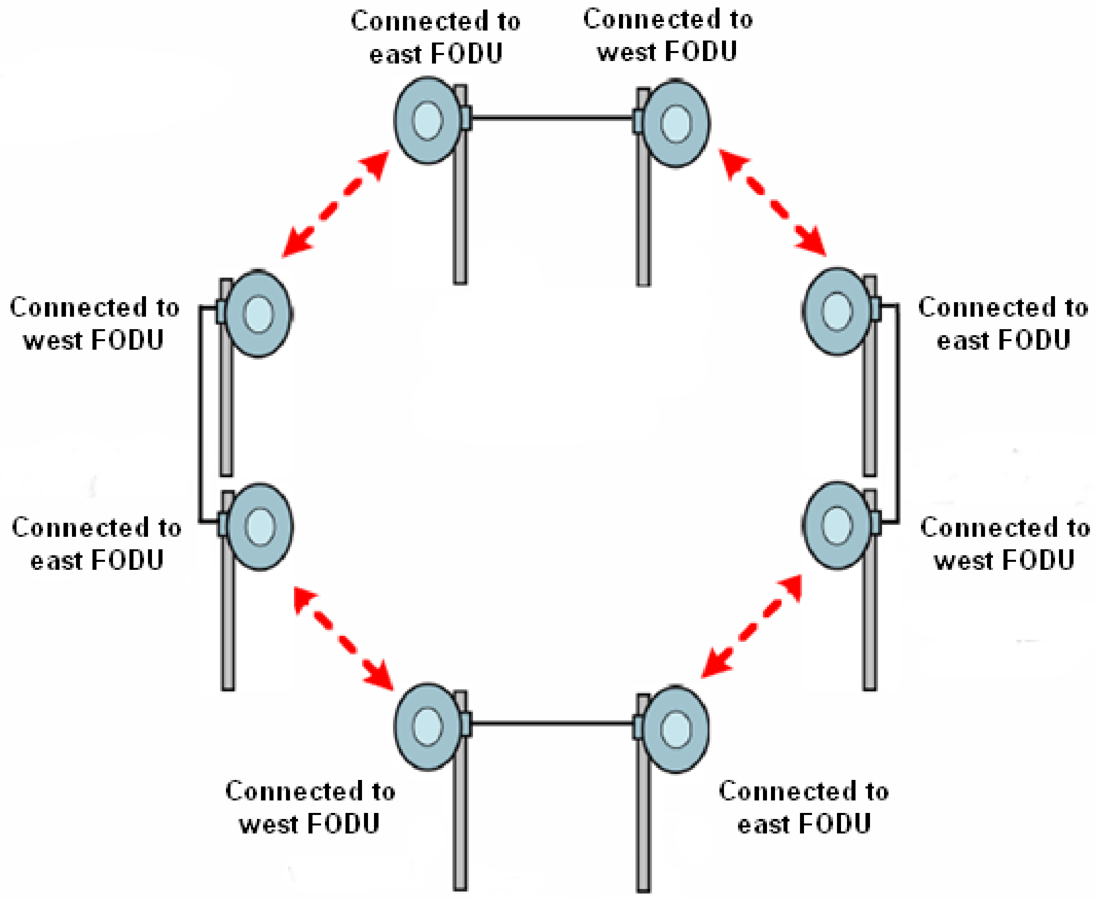
In a fiber environment the costs would enormous for dark fiber (est. $70K a mile - not including Right of Way leases, permits, provisioning time, physical security).

In a leased telco environment there can be mileage charges and lengthy contracts.

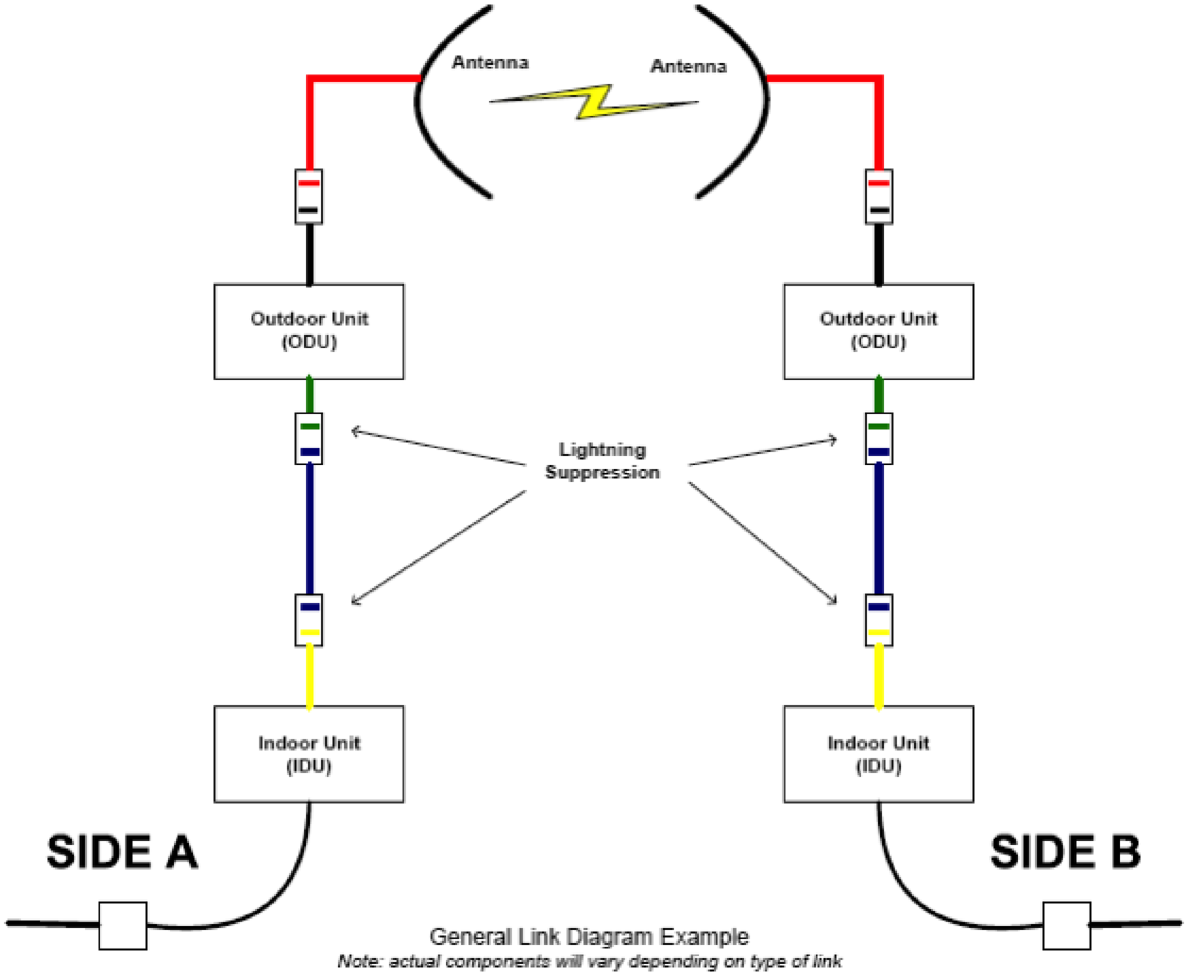
IP Networking for Multi Use



Ring Topology



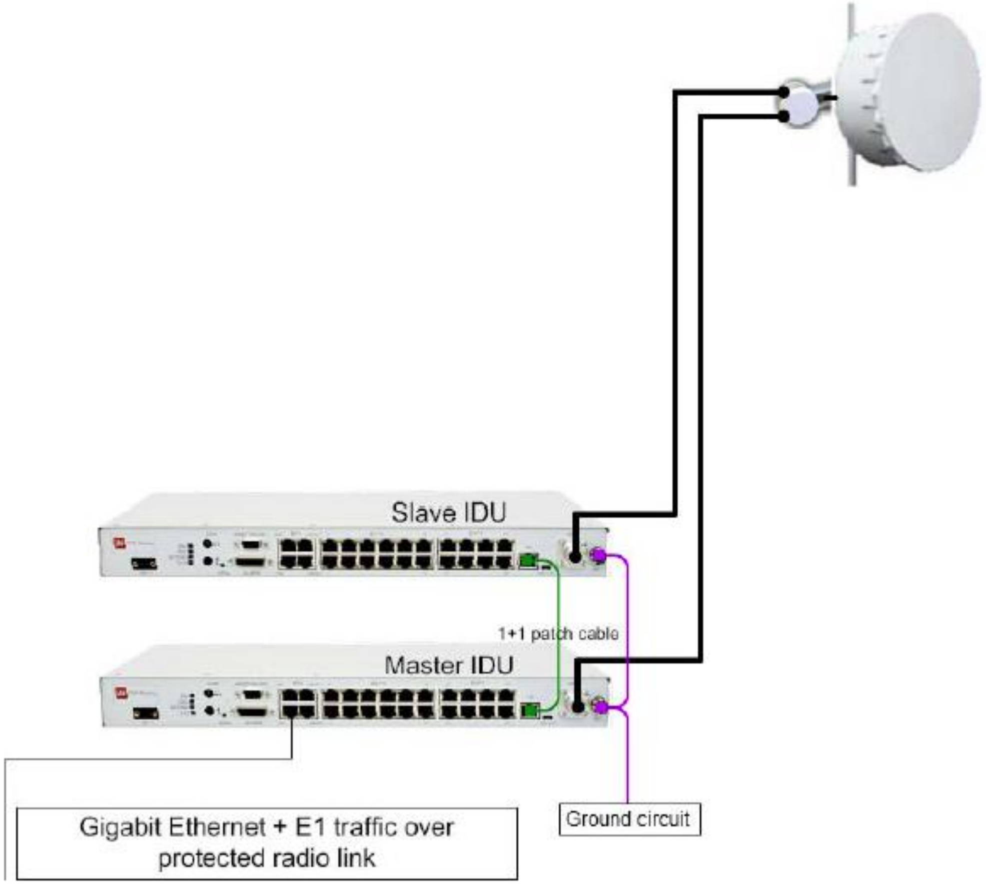
Typical Spit Mount System



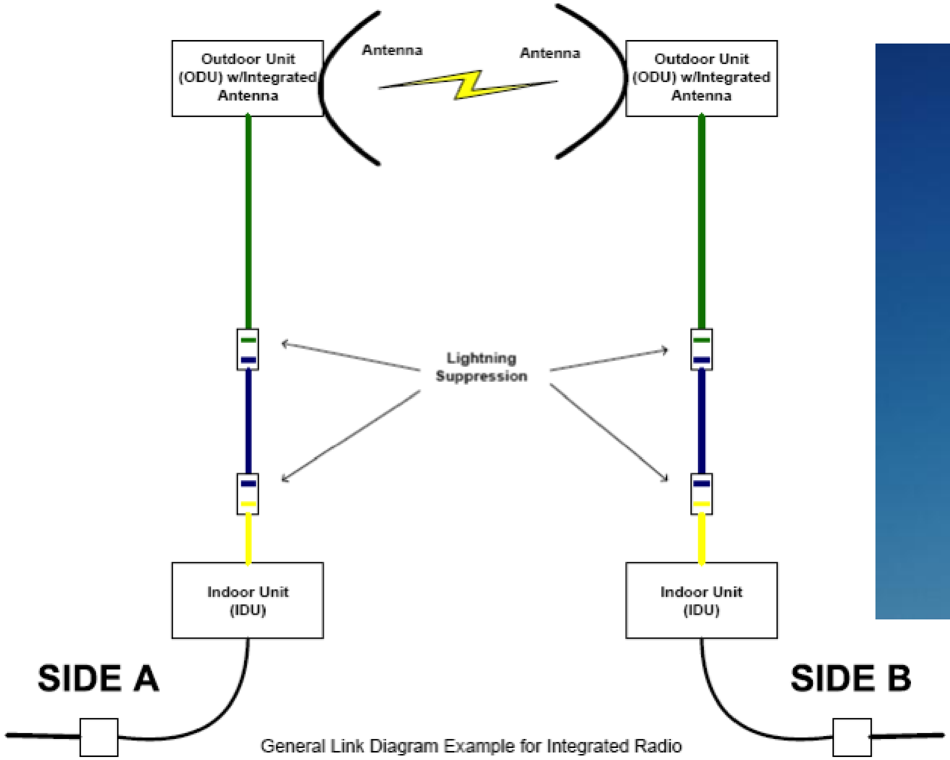
General Link Diagram Example

Note: actual components will vary depending on type of link

Typical Spit Mount System 2+0

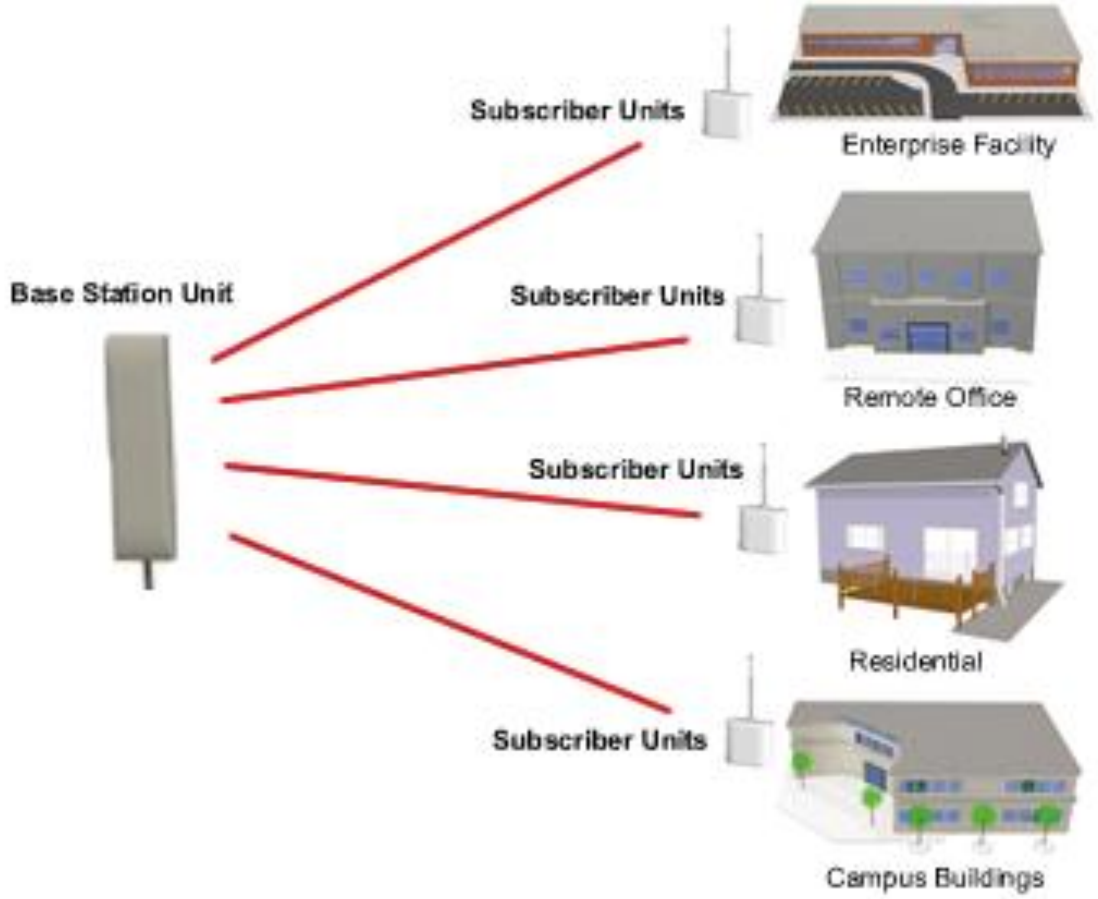


Typical All Outdoor System

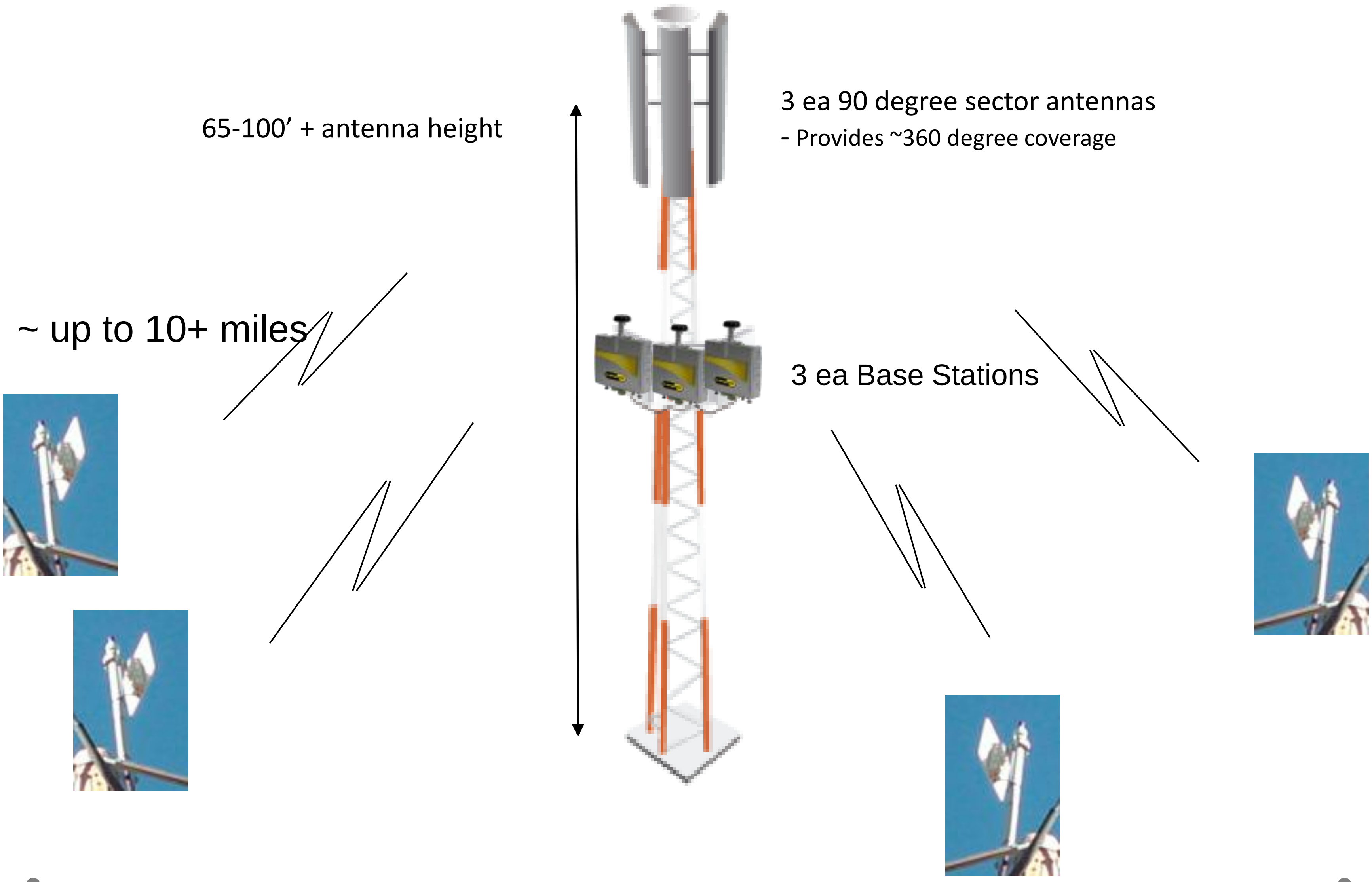


General Link Diagram Example for Integrated Radio
Note: actual components will vary depending on type of link

Point to Multi Point


Subscriber Units
Enterprise Facility
Base Station Unit
Subscriber Units
Remote Office
Subscriber Units
Residential
Subscriber Units
Campus Buildings

WiMax / LTE Typical Base Station Topology



65-100’ + antenna height

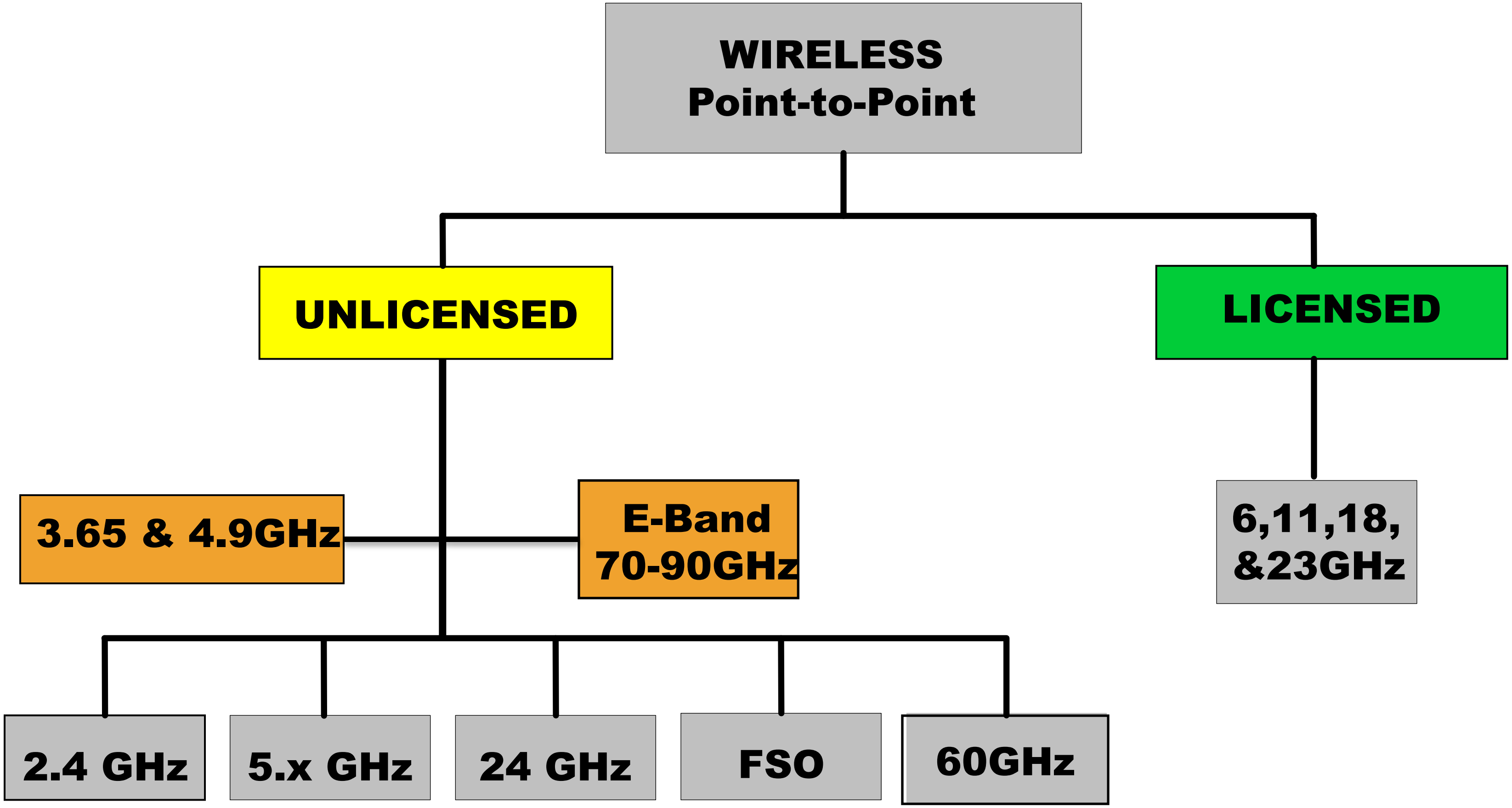
3 ea 90 degree sector antennas

- Provides ~360 degree coverage

~ up to 10+ miles

3 ea Base Stations

Understanding Frequencies



WIRELESS
Point-to-Point

UNLICENSED

LICENSED

3.65 & 4.9GHz

E-Band
70-90GHz

6,11,18,
&23GHz

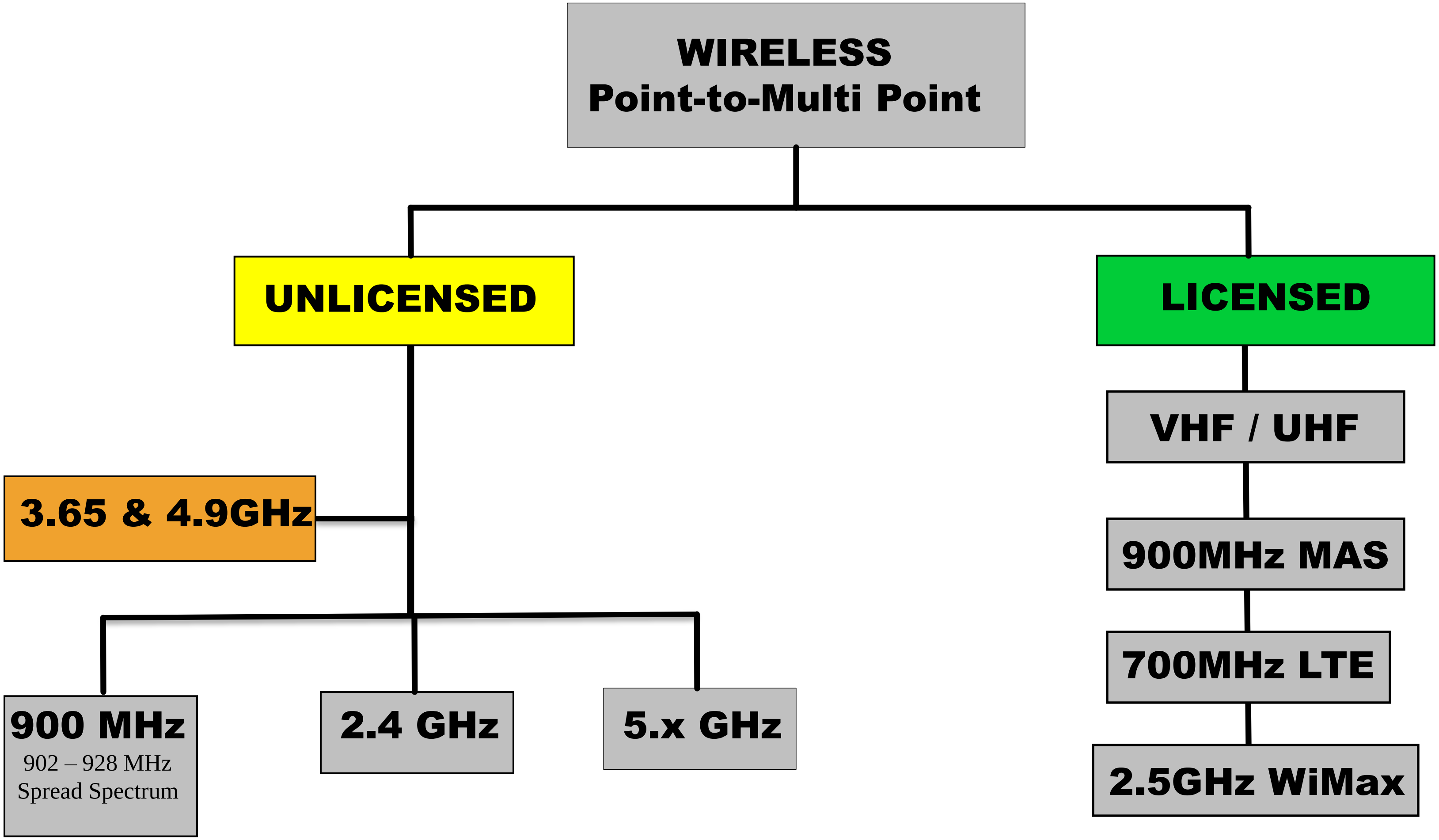
2.4 GHz

5.x GHz

24 GHz

FSO

60GHz



WIRELESS
Point-to-Multi Point

UNLICENSED

3.65 & 4.9GHz

900 MHz
902 – 928 MHz
Spread Spectrum

2.4 GHz

5.x GHz

LICENSED

VHF / UHF

900MHz MAS

700MHz LTE

2.5GHz WiMax

Licensed vs. Unlicensed

Licensed

- High Bandwidth (GigE+)
- 1+1, 2+0, 3+0, 4+0 Redundancy
- Configurations
- Full Duplex (FDD)
- Immune to Interference
- Extreme Low Latency (<1ms / μs)
- Enterprise and Carrier Grade
- 99.999% Reliability
- 20+ Years MFT
- Non- Wi-Fi components

Unlicensed

- Limited Bandwidth (up to 300Mbps Aggregate
- No True Redundancy
- Half Duplex (TDD)
- Susceptible to **Interference**
- Low Latency (<2ms)
- Value Line and Enterprise Grade
- 99.999% Only at time of install
- Typical 5 year MFT
- Typical Wi-Fi Chipsets

Security

Wireless networks have several layers of security:

- **AES - 128bit & 256bit encryption**
- **Proprietary encoding and decoding encryption**
- **Narrow beam width**
- **Https , MAC control, Radius, etc.**
- **Partner paired**
- **Network monitoring**
- **Meets DOD specifications**

Understanding Interference

Wireless Interference

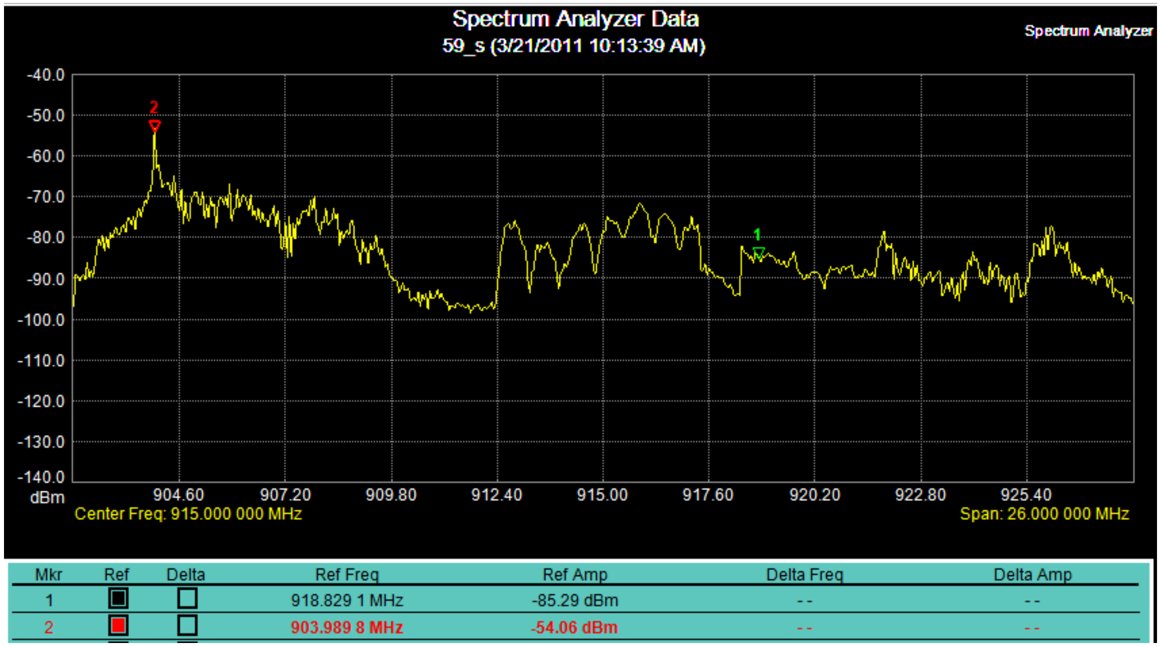
- Wireless interference can cause fading or noise on the receiving wireless antenna lowering the quality of signal.

- Noise is often measured by SNR (“signal to noise ratio”) or a relationship of the desired signal quality to the level of undesired or corrupting signal (background noise).

- This can be thought of in terms much like that of listening to music. Even if the music you are trying to listen to is at a desired volume but there is a lot of background noise, it can be difficult to listen to the music.

- A wireless link will have a certain threshold of wireless interference it can overcome before experiencing issues. This is often referred to a wireless system’s CIR or carrier to interference ratio.

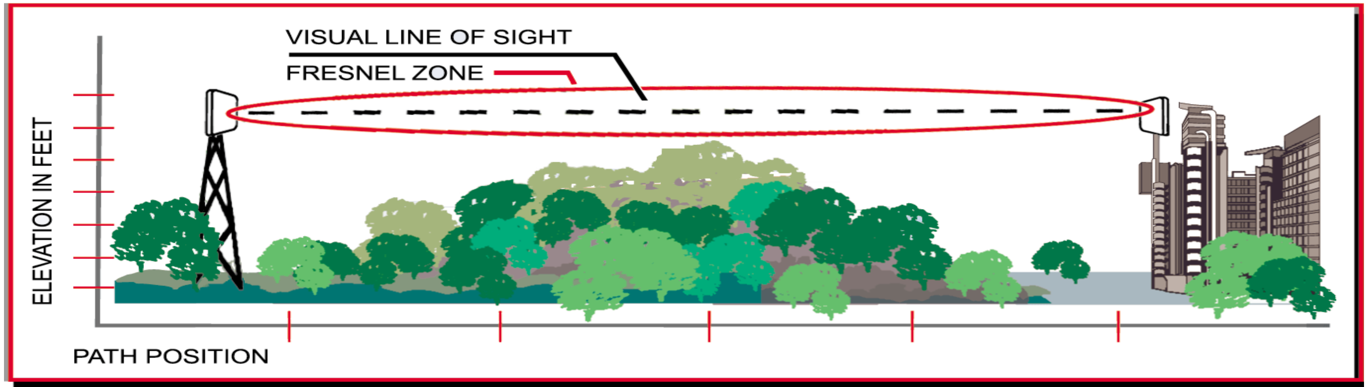
Wireless Interference Measured



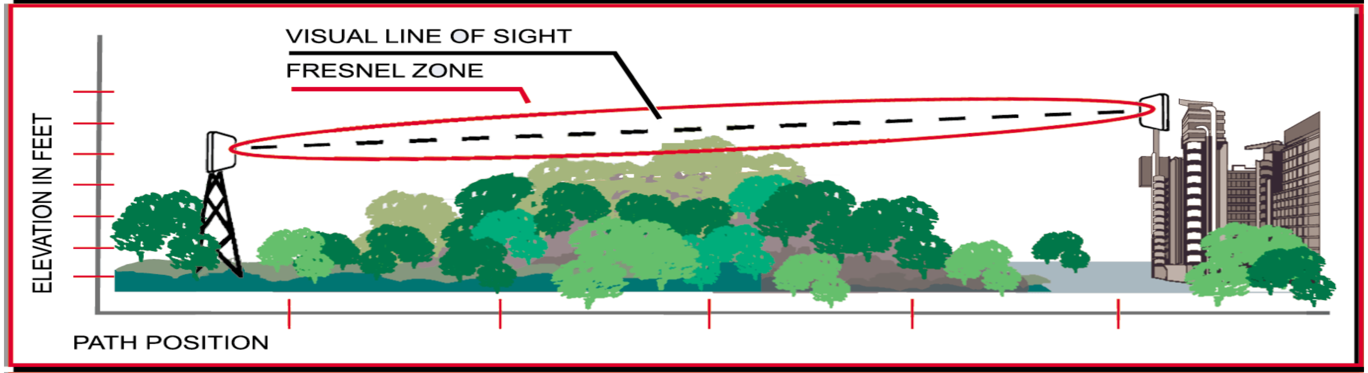
Mkr	Ref	Delta	Ref Freq	Ref Amp	Delta Freq	Delta Amp
1	■	☐	918.829 1 MHz	-85.29 dBm	- -	- -
2	🟥	☐	903.989 8 MHz	-54.06 dBm	- -	- -

For the purpose of this discussion “Wireless Interference” is defined as a wireless signal that alters, modifies, or disrupts the desired wireless signal as it travels from the transmitting source antenna to the receiving antenna.

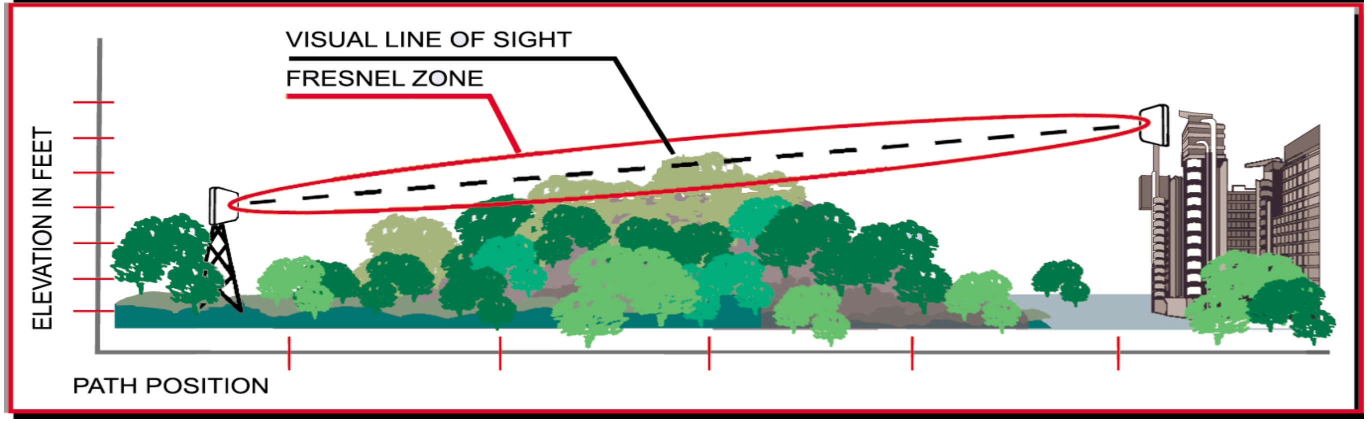
Understanding Path Design



Line of Site

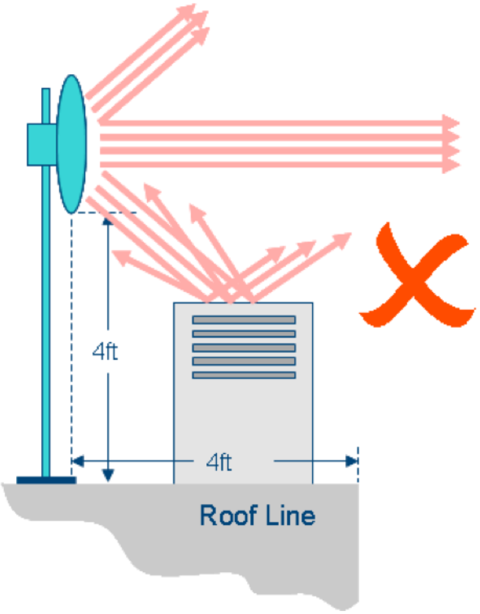


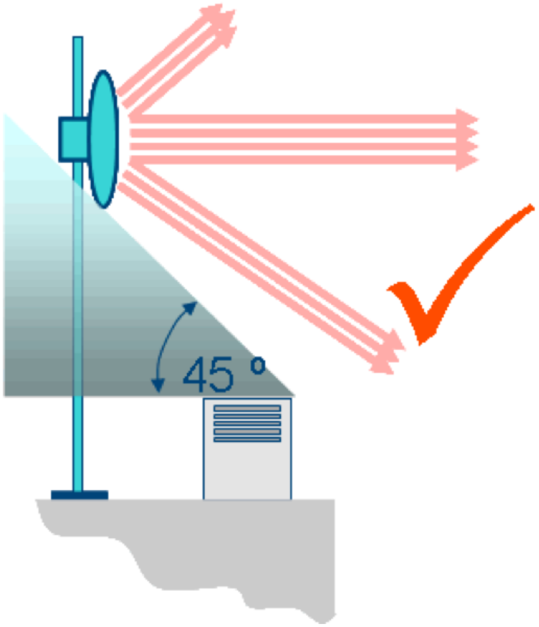
Near Line of Site



Non Line of Site

Self Reflective Interference

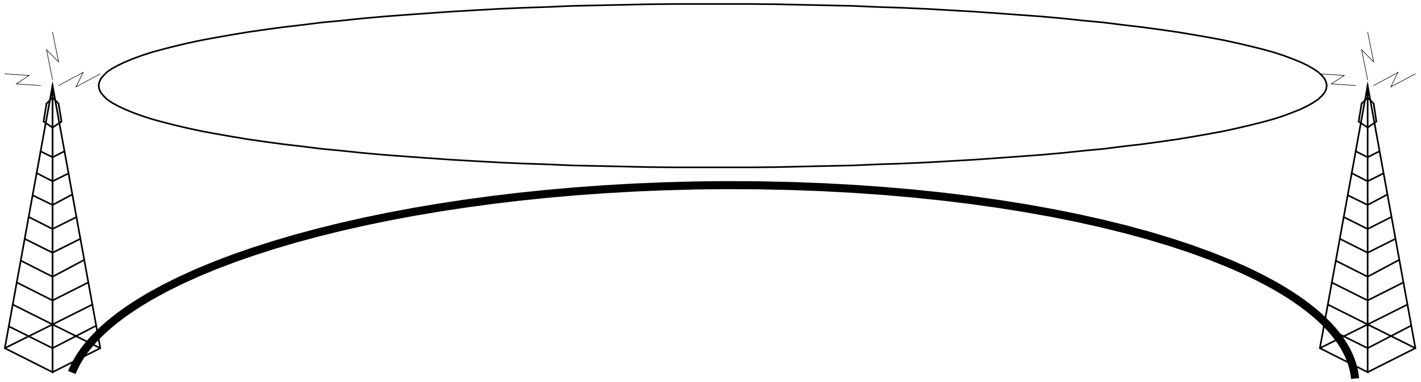




K Factor

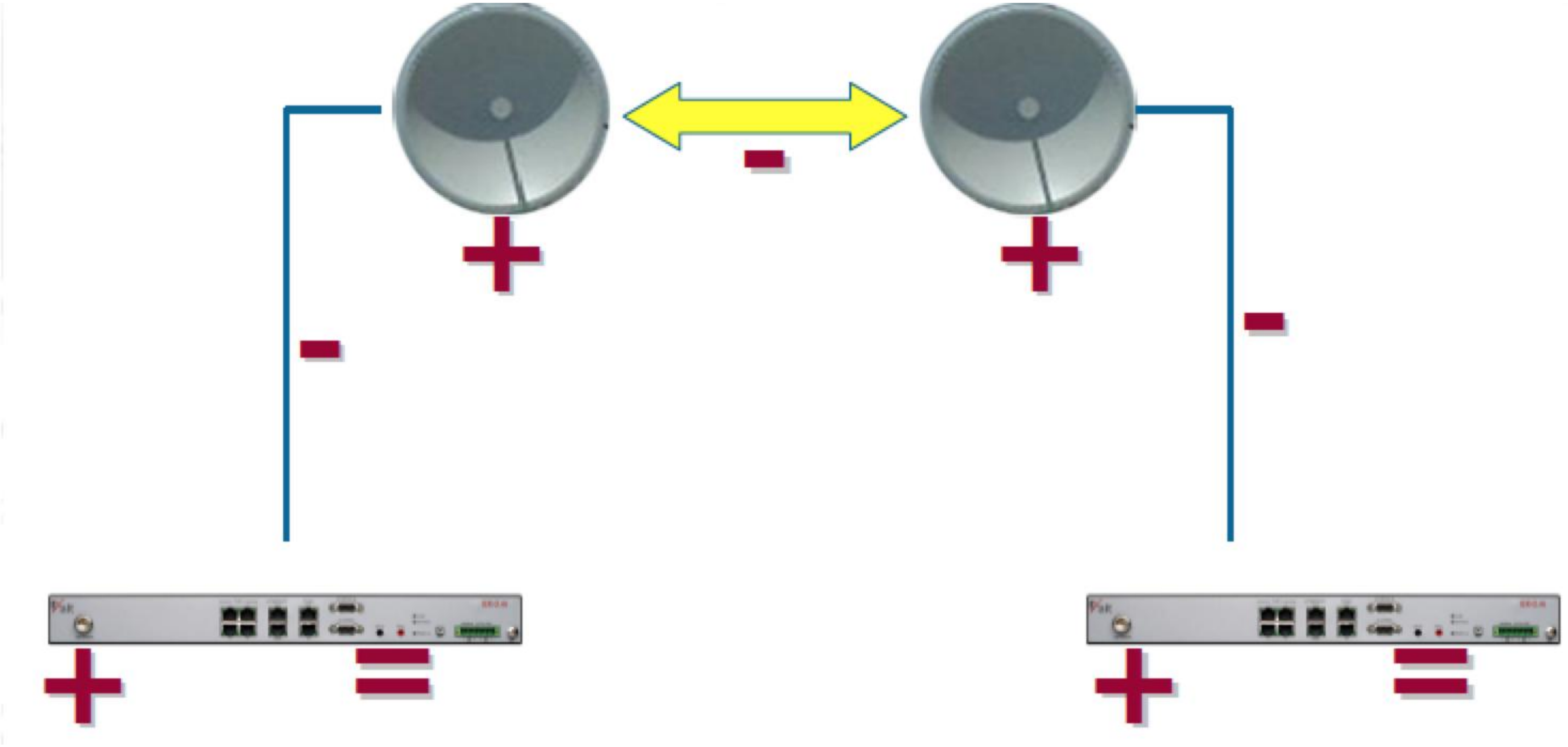
One factor for long distance paths includes earth curvature and the effects of the atmospheric refraction due to the curve of the earth’s surface

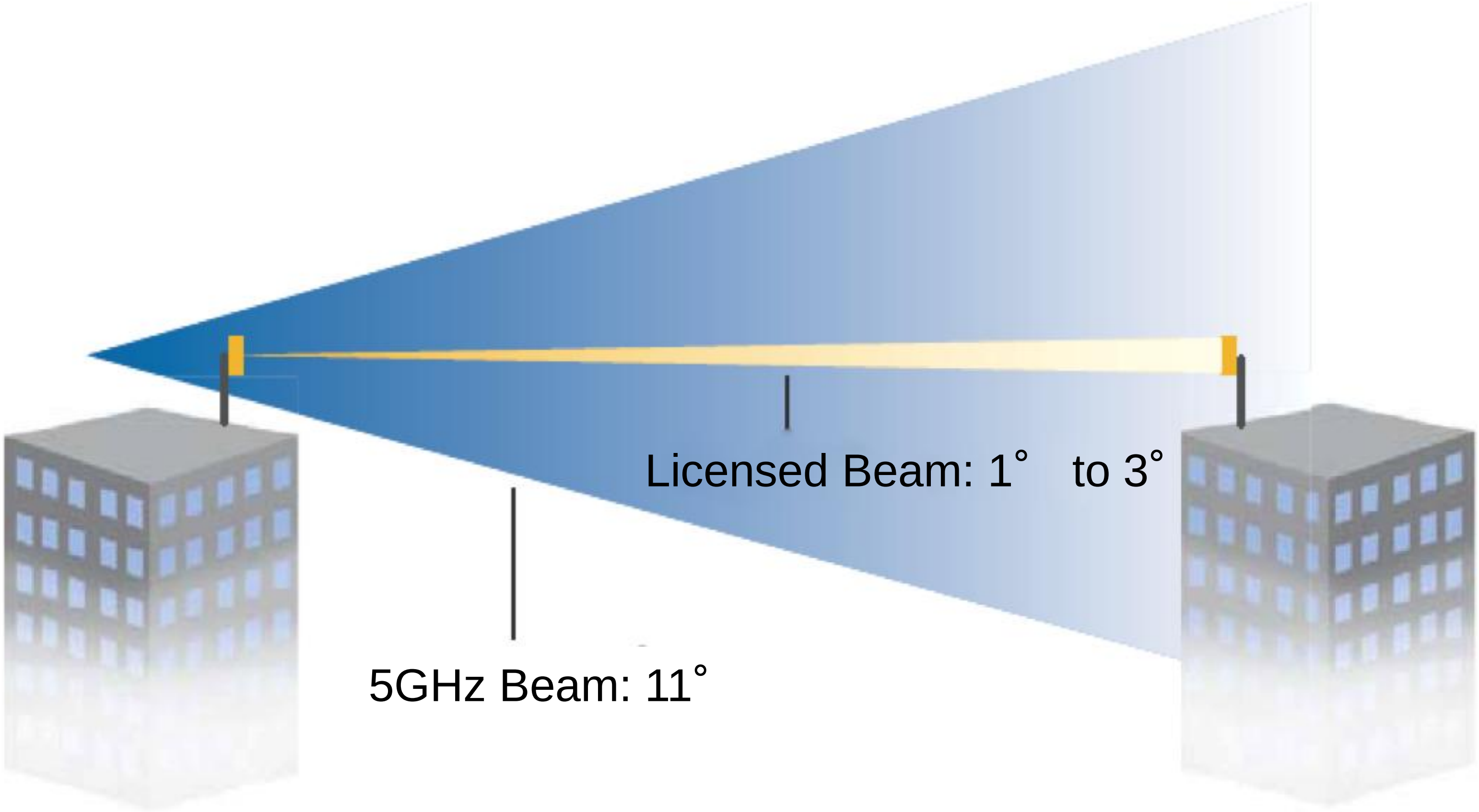
The earth’s bulge between the end points must be considered when determining if LOS and proper path clearance exists, including Fresnel zone



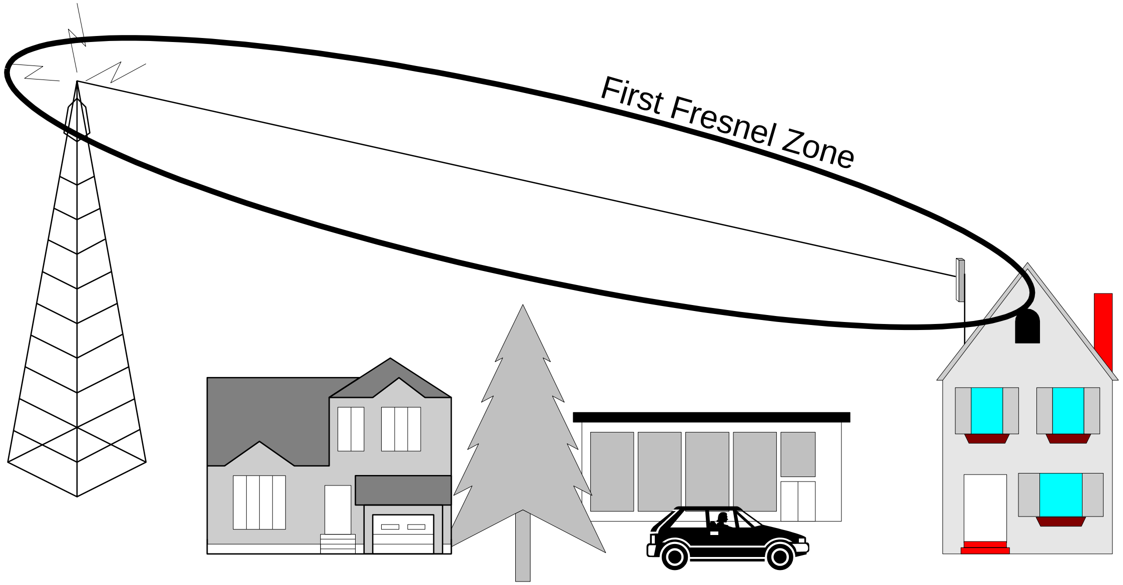
Not much of a factor under 10 miles

System Gain




Licensed Beam: 1° to 3°
5GHz Beam: 11°

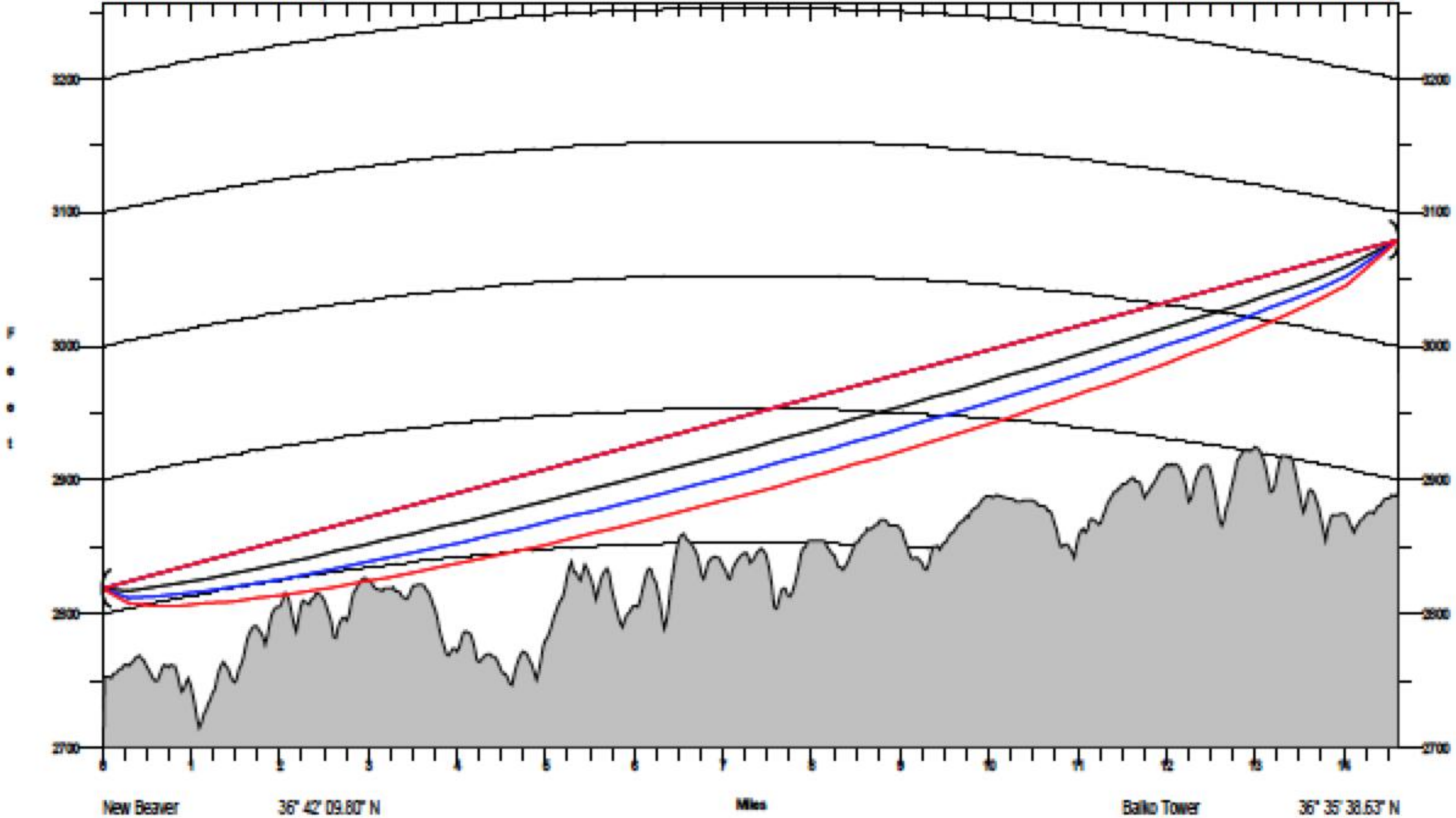
Fresnel Zone



To maximize receiver strength, one needs to minimize the effect of the out-of-phase signals by removing obstacles from the radio frequency line of sight ("LOS"). The strongest signals are on the direct line between transmitter and receiver and always lie in the first Fresnel Zone.

Path Distance: 14.626 mi.
Tx LOS Path Inclination: 0.1936 deg.

Tx LOS Path Inclination: -0.1936 deg.



New Beaver	36° 42' 09.80" N
	100° 31' 47.20" W
Elevation	2669.0 ft.
Ant. AGL - Tx/Rx/Div	150.0/150.0/0.0 ft.
Frequency - Tx	10775.00000 MHz
Azimuth	239.253 deg T

Balko Tower	36° 35' 38.63" N
	100° 45' 21.02" W
Elevation	2980.0 ft.
Ant. AGL - Tx/Rx/Div	100.0/100.0/0.0 ft.
Frequency - Tx	11265.00000 MHz
Azimuth	059.118 deg T

KEY: Profile

K = 2/3
K = 2/3, F = 0.6*F1
K = 2/3, F = 1
K = 2/3, F = 2

Predictable Reliability

- The predicted amount of time the system will be operating above threshold
- Availability is the primary design criteria for outdoor wireless systems
- Equation uses the following factors:
- Terrain
- Climate
- Frequency
- Distance
- Fade Margin

Examples (at full throughput – *Note: 99.999% can be achieved with ACM at lower throughputs*).

- **99.999%** = 5.26 minutes/year outage (“Five Nines”)
- **99.995%** = 26.28 minutes/year outage
- **99.950%** = 262.8 minutes/year outage

Advanced Modulation Ability to Improve Reliability

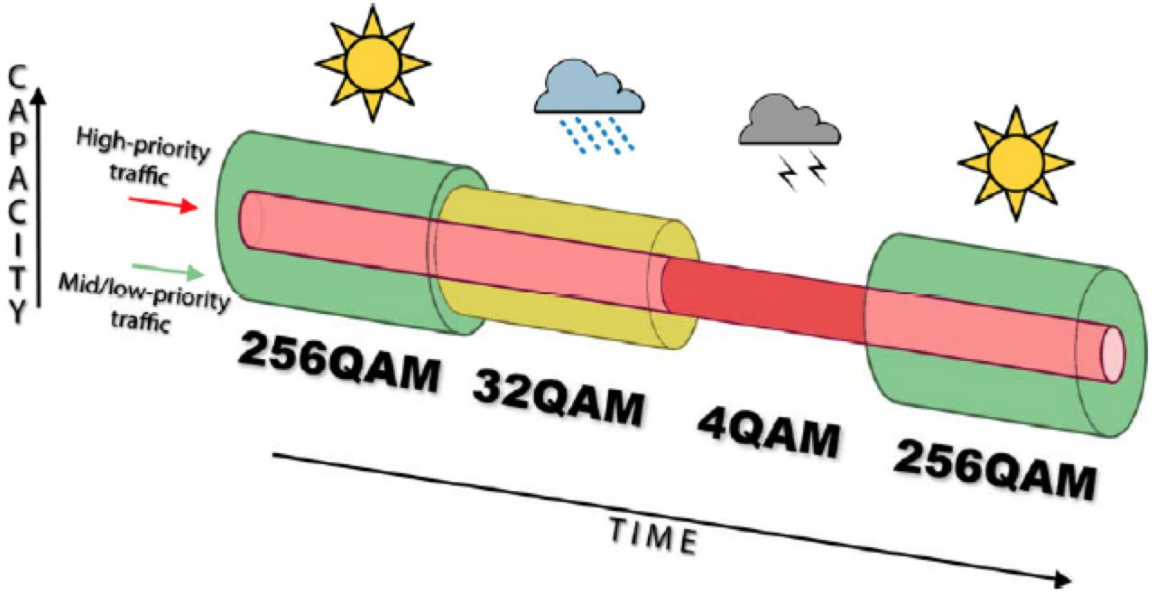


Figure 4.2. ACM bandwidth capacity adaptation

Full modulation range: 256QAM, 128QAM, 64QAM, 32QAM, 16QAM, 4QAM

Wireless in Utility Environment

Licensed WiMax

802.16e standard for the multipoint backhaul tier

Multi Service

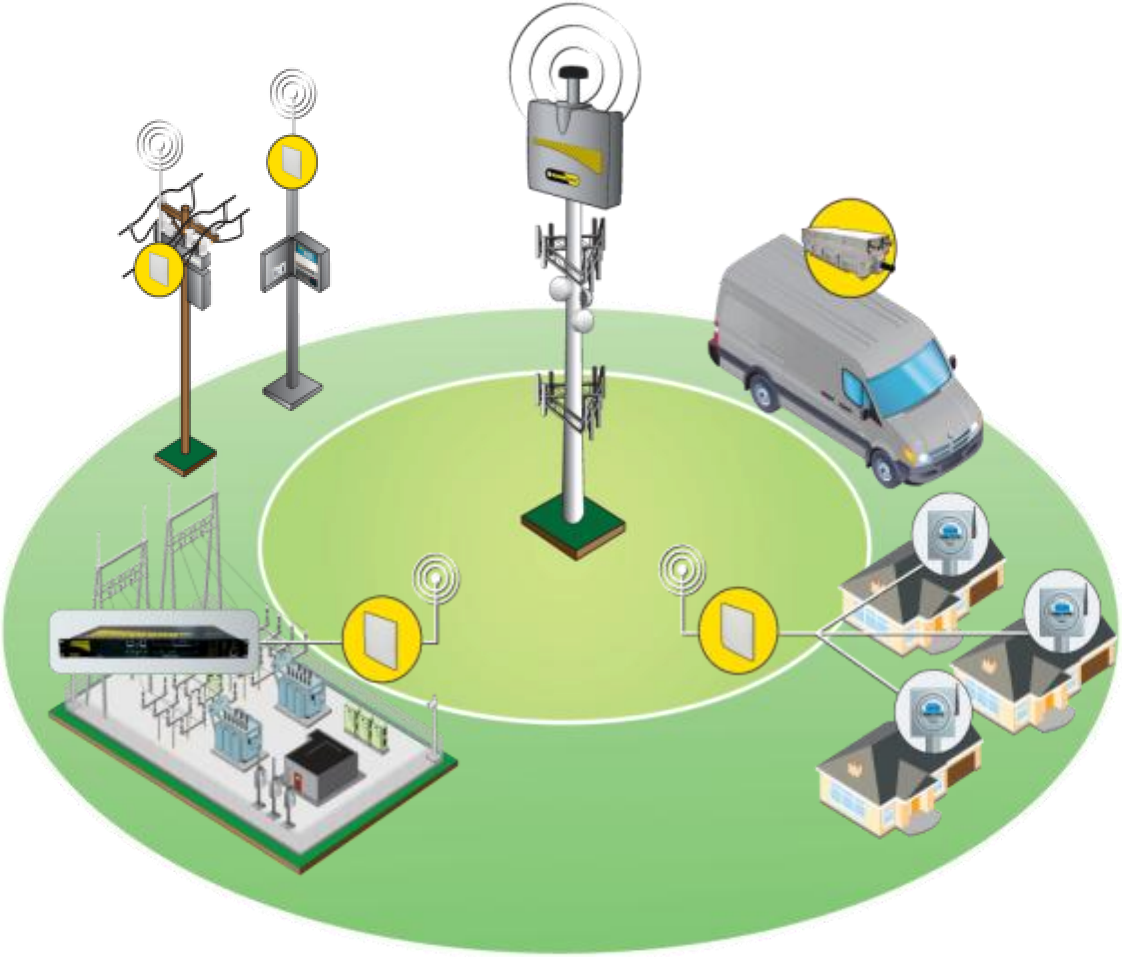
- AMI Backhaul
- SCADA connectivity
- Distribution Automation
- Mobile Workforce

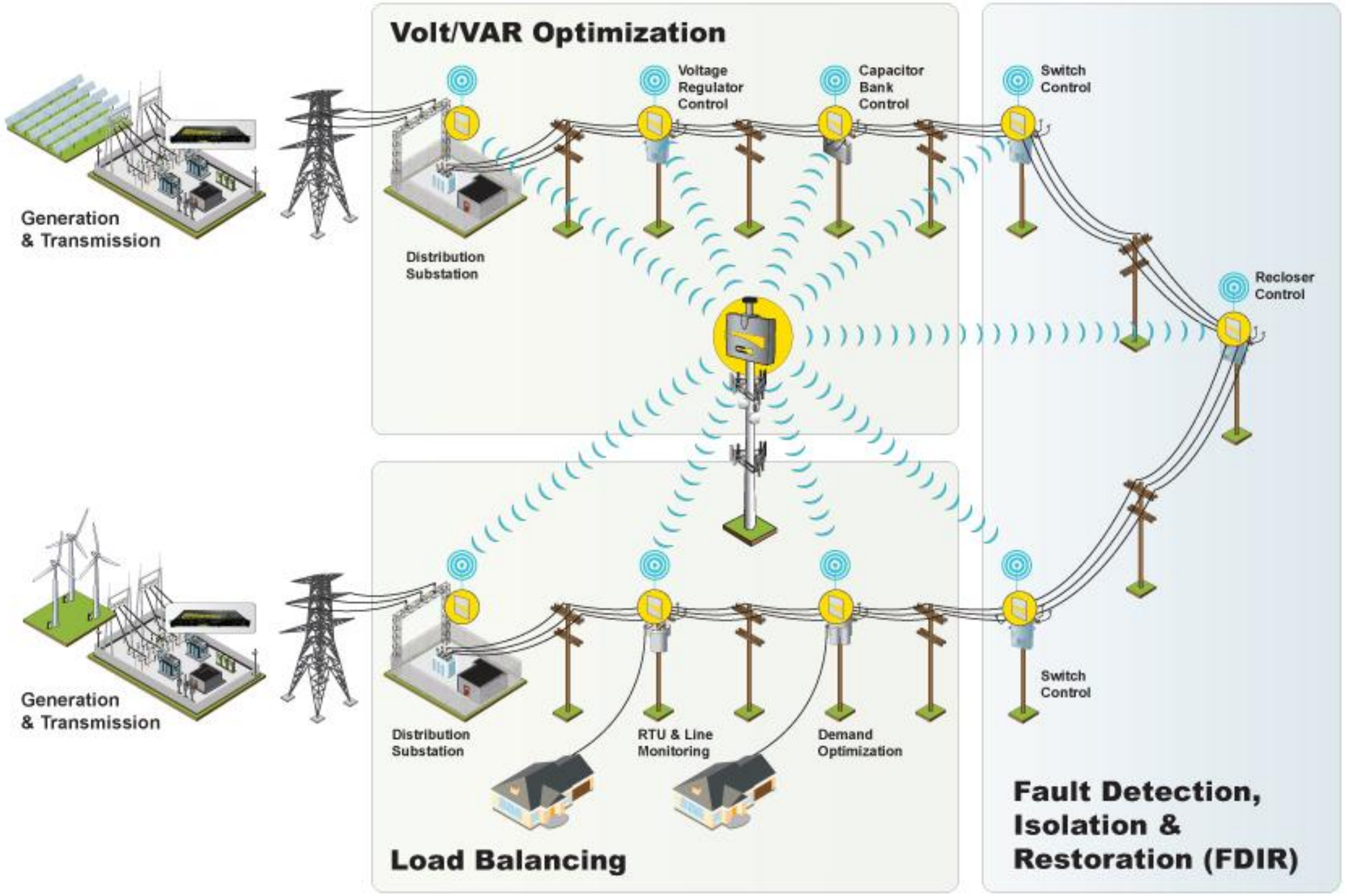
Broadband Rates

- 10-100Mbps+ Mb/s throughput

Wide Area Coverage

- 5 to 10 miles+ Range

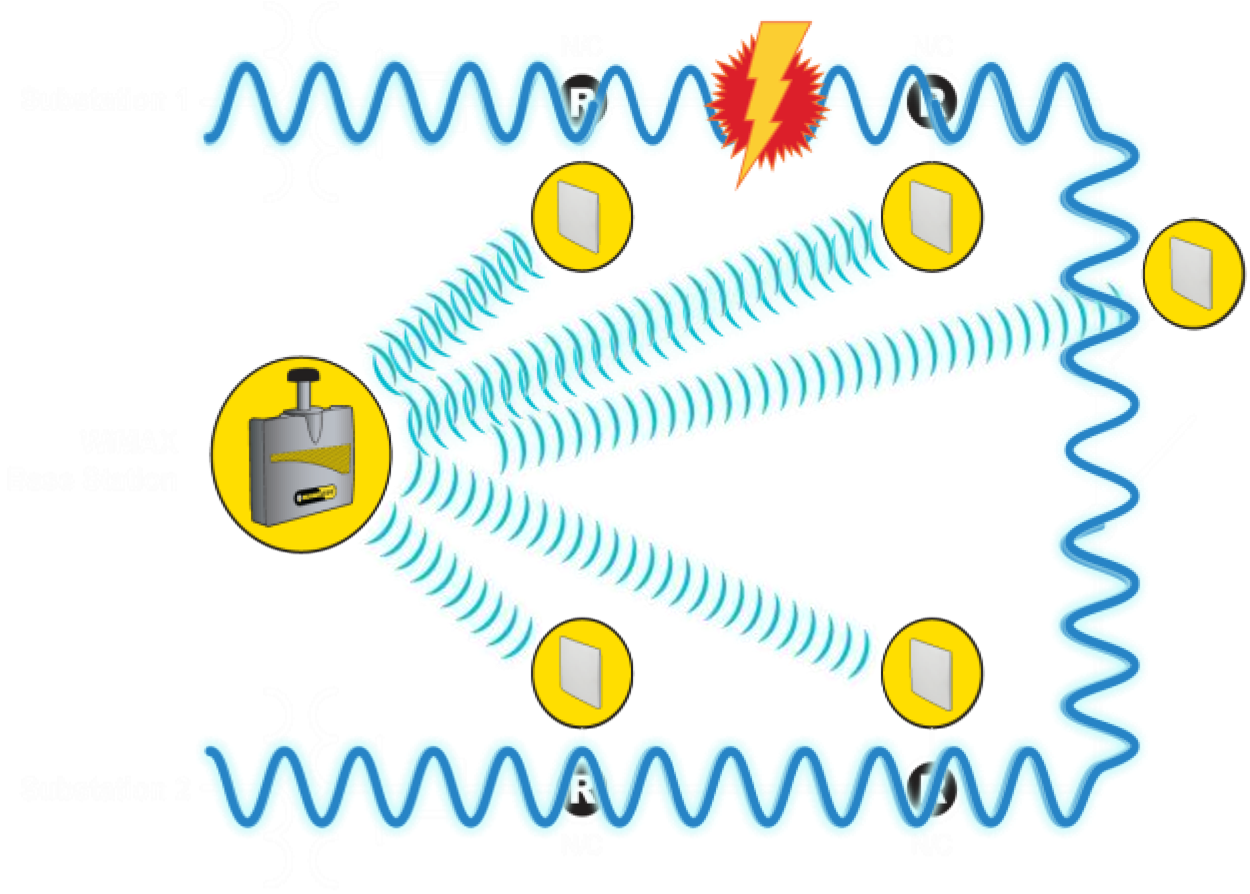



Volt/VAR Optimization
Voltage Regulator Control
Capacitor Bank Control
Switch Control
Generation & Transmission
Distribution Substation
Recloser Control
Generation & Transmission
Distribution Substation
RTU & Line Monitoring
Demand Optimization
Switch Control
Load Balancing
Fault Detection, Isolation & Restoration (FDIR)

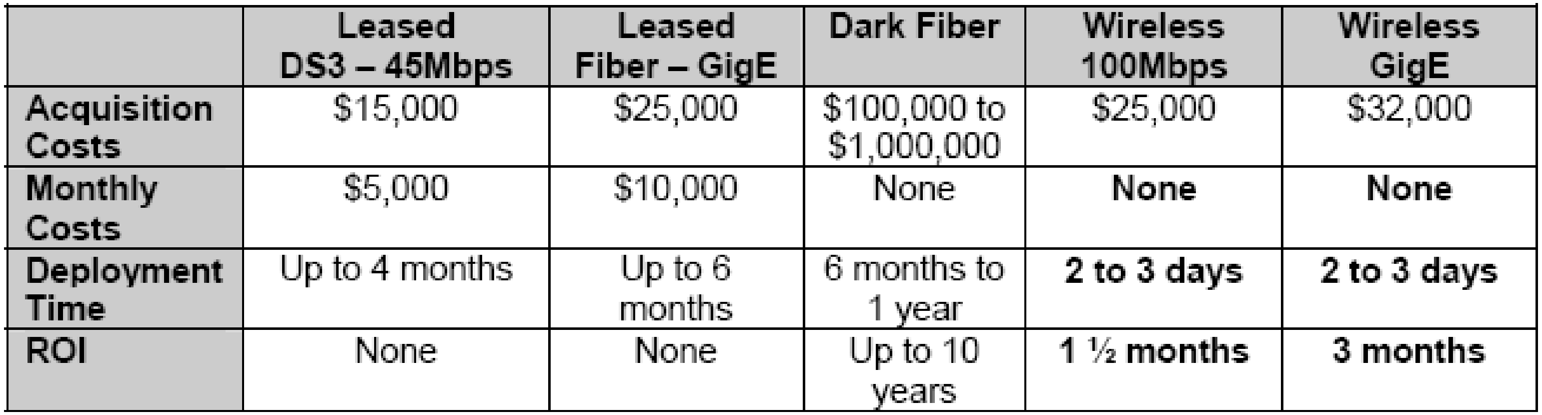
Distribution Automation

Fault Restoration

- Stand alone mode for optimized QOS and latency performance
- Direct Layer 2 Forwarding



Typical Wireless Link ROI



	Leased DS3 – 45Mbps	Leased Fiber – GigE	Dark Fiber	Wireless 100Mbps	Wireless GigE
Acquisition Costs	$15,000	$25,000	$100,000 to $1,000,000	$25,000	$32,000
Monthly Costs	$5,000	$10,000	None	**None**	**None**
Deployment Time	Up to 4 months	Up to 6 months	6 months to 1 year	**2 to 3 days**	**2 to 3 days**
ROI	None	None	Up to 10 years	**1 ½ months**	**3 months**

Use Only Professional Installations

NATE
National Association
of
Tower Erectors

ComTrain LLC

OSHA

Myths About Wireless

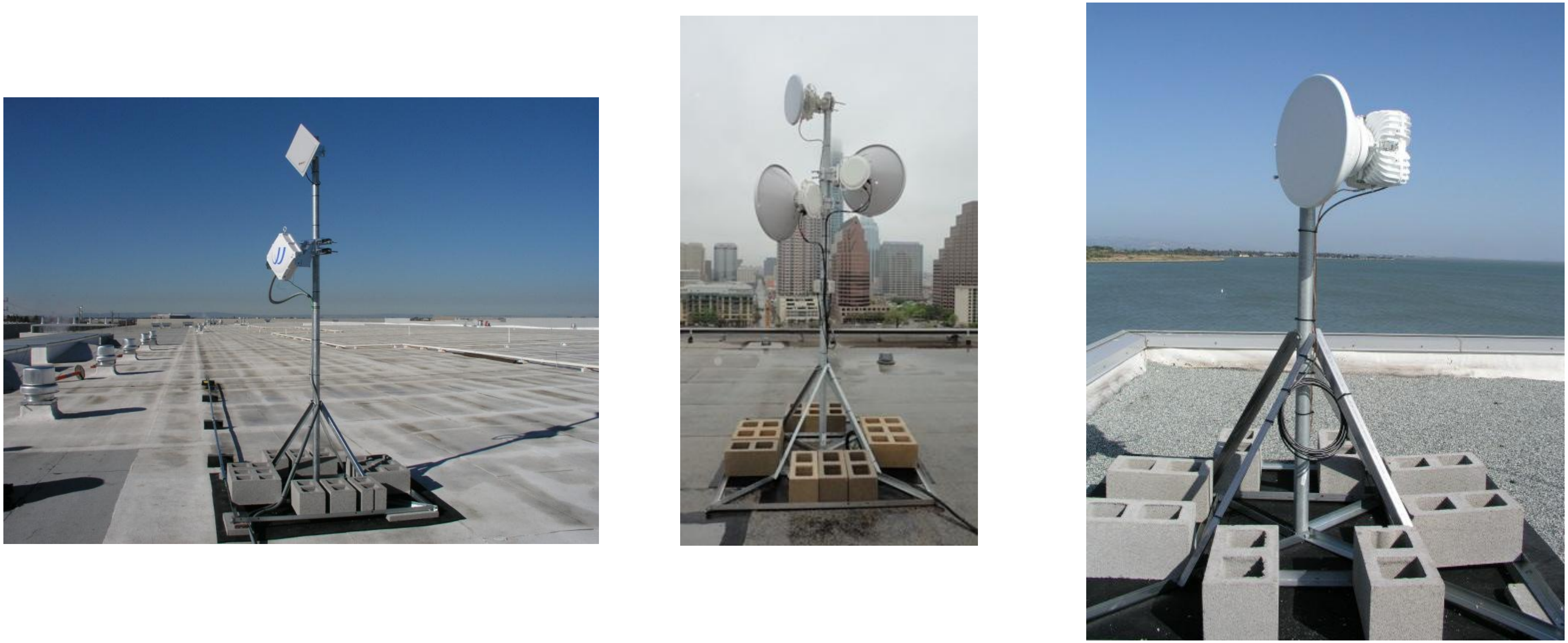
- Is wireless communication reliable? **Yes! If properly designed, engineered, and installed correctly 99.999% can be achieved**.

- Is wireless secure? **Can meet DOD security standards.**

- Is wireless comparable to fiber? (Speed & Latency) **Yes! Wireless can match the performance of fiber but can have other advantages. Wireless is also a great way to create true redundancy to existing fiber networks.**

- Is it expensive to have licensed wireless? **No. Today the costs of Enterprise / Carrier grade unlicensed and licensed wireless equipment is about the same. The costs for owning a FCC license is nominal.**

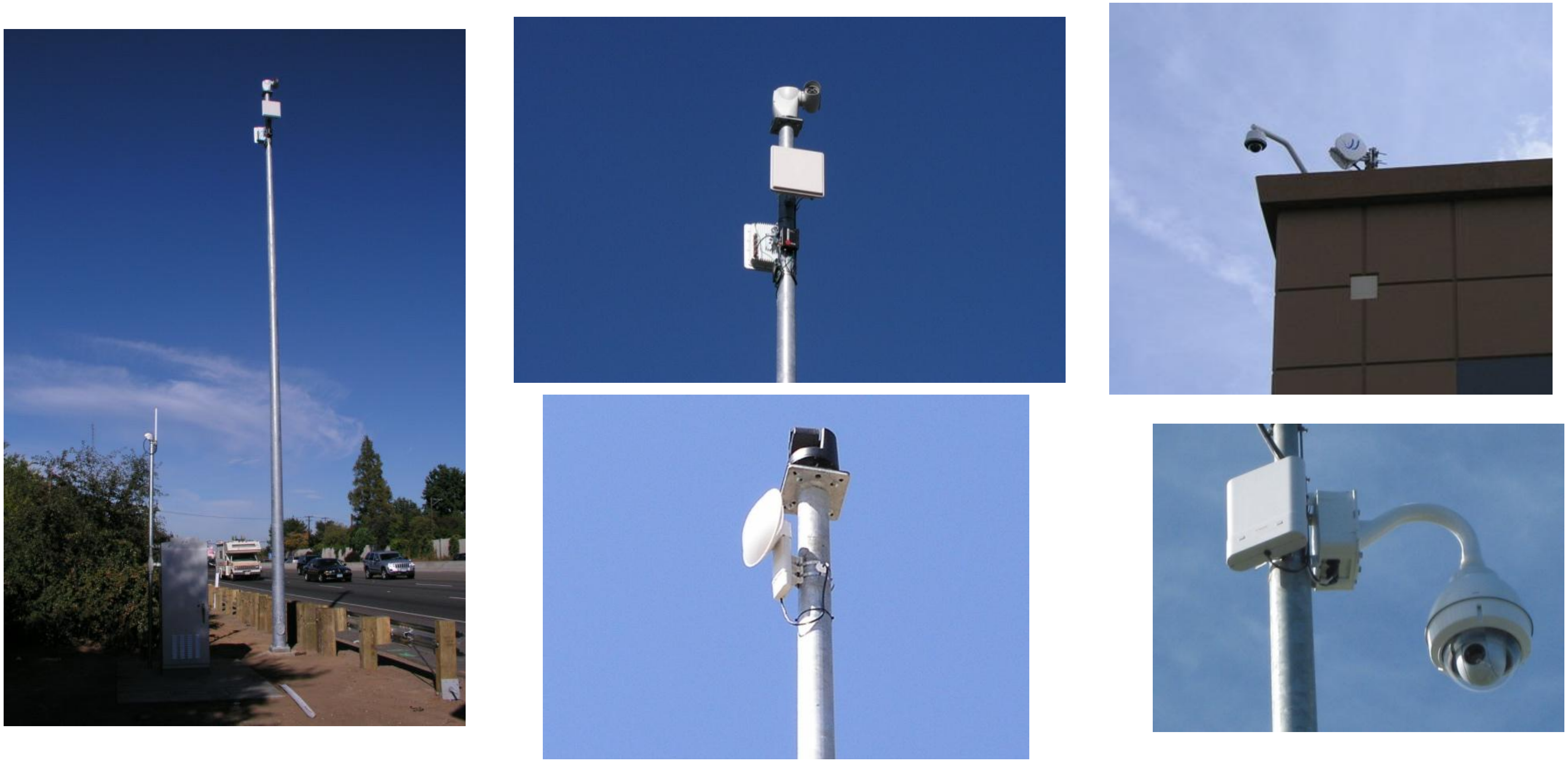
Examples of Non- Penetrating Roof Mount Masts



Examples of Tower Installations

Examples of Tower Builds

Video Backhaul Over Wireless



Video Surveillance Anywhere

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